WASTE HEAT RECOVERY HEAT PIPE

INVENTRONICS LTD.

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MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources — oil and natural gas — are becoming less accessible and more costly. However, Canada is well-endowed with renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminated March 31, 1984. The Agreement was dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program had a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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EXECUTIVE SUMMARY

A heat pipe unit was installed at Inventronics Limited, Brandon, to reclaim waste heat from a paint drying oven exhaust stream. The recovered heat is used for space heating. The system was monitored for a one month period, and a saving of 9.2% ($337.00) of gas consumption was calculated. The savings over a full heating season (November 1 to April 1) was estimated to be $1,685, resulting in a simple payback period of 10.4 years for a two shift operation.

RÉSUMÉ ADMINISTRATIF

Un calcduc a été installé aux établissements Inventronics Limited, à Brandon, afin de récupérer la chaleur des gaz d'échappement d'un four de séchage de peinture. La chaleur récupérée a servi à chauffer les locaux. Le système a été contrôlé pendant un mois et on a calculé qu'on avait économisé 9,2% du prix du gaz, soit 337,00 dollars. Sur une période de chauffage complète (du 1er novembre au 1er avril), on a évalué la somme économisée à 1 685 dollars - ce qui signifie une période de récupération de 10,4 années, en supposant deux équipes de travail par jour.

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INTRODUCTION

Inventronics Limited produces a variety of sheet metal products. These products are pre-treated with various chemicals before painting. After treatment, all parts are forced-air dried in an industrial drying oven.

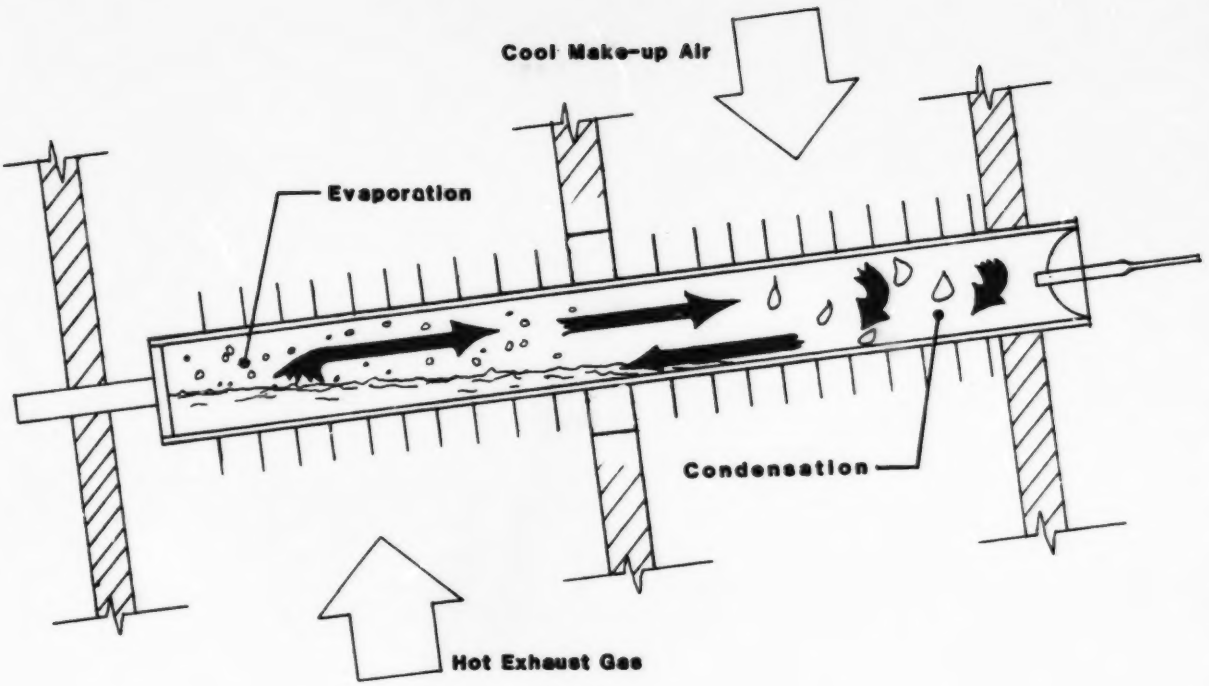
Waste heat from the drying oven was chosen as a source for heat recovery. Heat recovered from the oven exhaust air is used to condition incoming air for space heating.

Since direct mixing of the exhaust and incoming air is not possible due to the toxic properties of this exhaust, a Q-DOT TRU (Thermosyphon Recovery Unit) counterflow air to air heat exchanger was chosen.

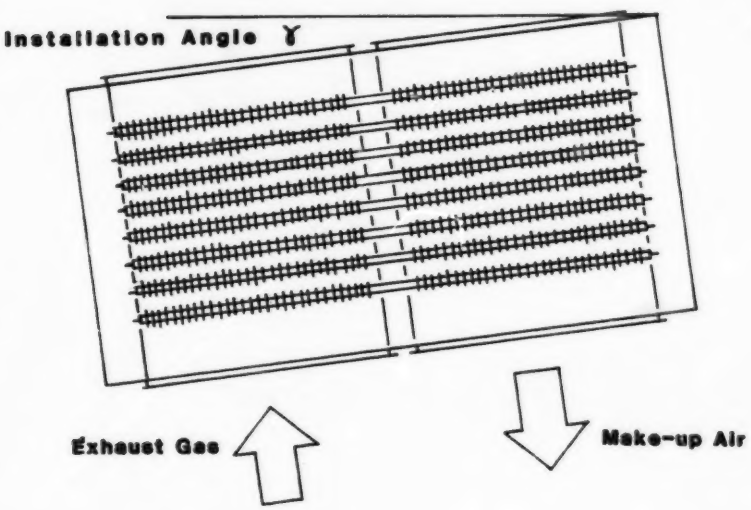
DESCRIPTION

The thermosyphon heat pipe is a hermetically-sealed metal tube which contains a refrigerant at low pressure (Figure 1). The heat recovery unit, as normally supplied, is made up of a number of finned thermosyphon tubes which breach the exhaust stream and make-up air plenums. When heat is applied at the exhaust stream end of the heat pipe, the refrigerant vapourizes and flows to the other end of the tube. At this end, the vapour condenses as sensible and latent heat is released to the incoming make-up air, via the tube walls and finning. The condensate, influenced by gravity and a capillary wick, then flows back to the hot end and the cycle is repeated.

The thermosyphon design was chosen for this project to avoid cross-contamination between the make-up air and exhaust streams, and to decrease the effect of fouling of the exchanger surfaces in the exhaust stream. The high efficiency of the heat pipe allows operation a higher level of fouling than is possible with more common heat transfer designs.



Cross-section of a Single Thermosyphon Tube



Front Elevation View of a Thermosyphon Recovery Unit

Figure 1

At Inventronics Limited, the recovery of waste heat yields a potential savings equivalent to the cost of natural gas that would be required to produce the recovered amount of heat. Figure 2 illustrates the installation.

Outside air is brought in at ambient temperature. If the air is above 18°C (65°F) it bypasses the heat exchanger and is used directly as make-up air. Air below 18°C passes through the exchanger and is used to heat the factory.

EXPERIMENTAL RESULTS AND DISCUSSION

The use of heat pipes can be complicated by the sensitivity of the units to angle of installation and by the necessity for running the heat source and sink streams in close proximity to each other (see Figure 1).

Only two problems were encountered when the unit was installed. First, workmen inadvertently dislodged dirt from the drying oven roof. This dirt caused temporary paint finish problems. Second, a bearing on the fan that distributes the warm air for space heat failed. The cause of this failure could not be determined. The fan has not failed since repair.

No problems have been experienced with fouling of the heat pipe. The thermosyphon heat exchanger is well suited for this type of industrial environment. The heat pipe prevents cross-contamination of the make-up air stream, and the high efficiency, low fouling and corrosion-resistant design makes this type of exchanger superior for recovering heat from fouling waste streams.

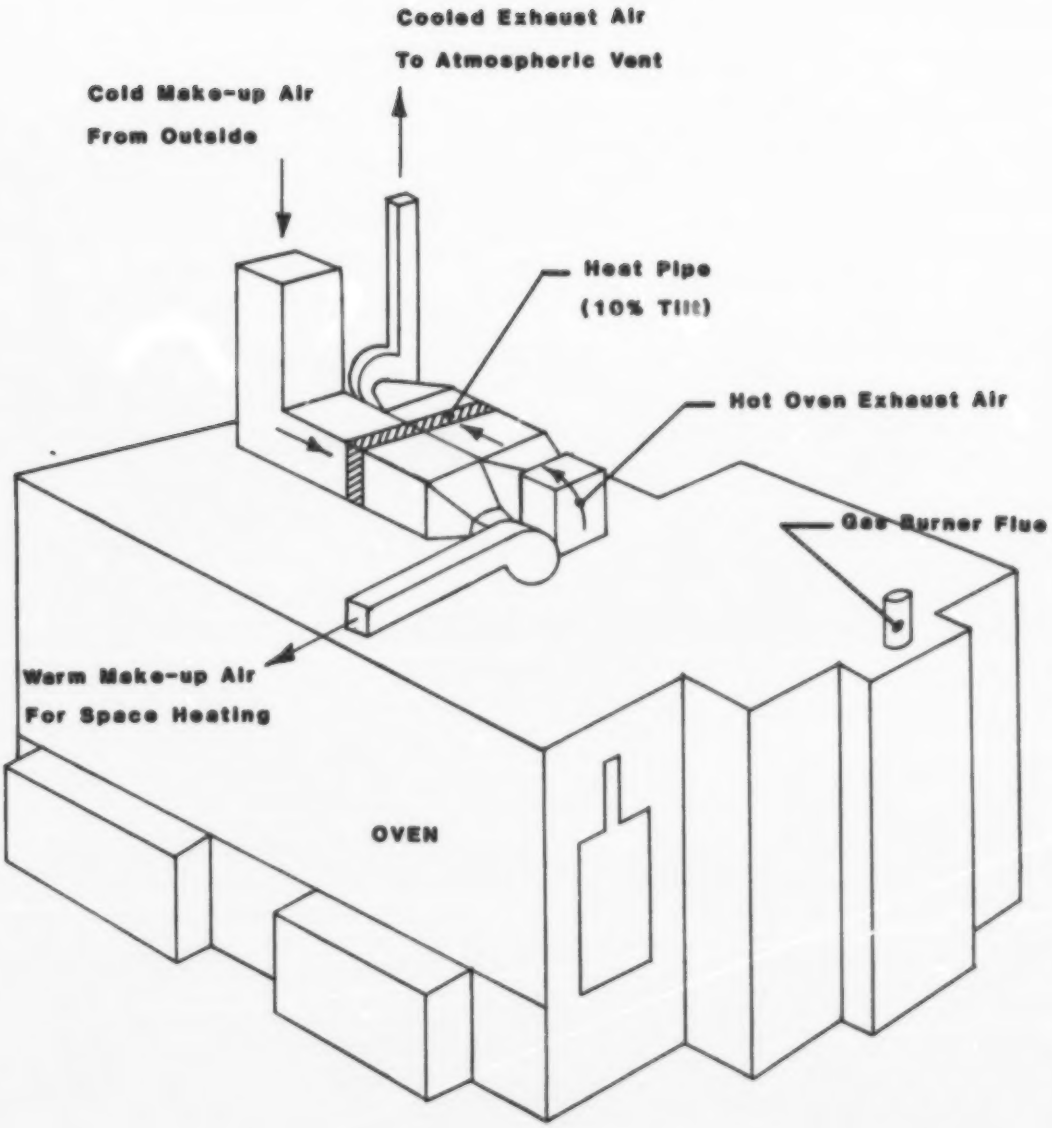


Figure 2 Oven Heat Pipe Recovery Unit Installation

The Inventronics manufacturing plant has only two main gas meters and no provisions for sub-metering the gas consumption of individual units. Therefore, actual pre- and post-demonstration gas consumption figures were not available to allow direct calculation of the savings in space heating costs achieved by the installation of the heat pipe unit.

Instead, the average heat recovery has been estimated using results from a one month monitoring period (Table 1). During the month of February, 1985, the make-up air flow rate, the oven exhaust, cold air inlet and make-up air outlet temperatures were monitored. The average make-up air inlet temperature was -27°C (-17°F) and the average outlet temperature was 14°C (57°F).

Savings for the five month heating season can be projected using the data acquired for the month of February (Table 1). However, the projected savings of $1,685 may be overly optimistic for the entire period. February is one of the coldest months of the season; the seasonal efficiency may be expected to be less because the temperature differential driving the transfer will be less in the shoulder months.

TABLE 1

Measured Heat Recovery

(based on one month operating period)

Average recovery unit air inlet temperature (ambient)...	-17°F
Average recovery unit air outlet temperature.....	57°F
Temperature gain..... 57 - (-17.5) =	74.5°F
Average oven exhaust temperature.....	215°F
Fan output.....	2400 SCFM
Total operating time (one month) = ...	442 hr.
Fuel cost.....	$3.95/million BTU

Q = heat recovery rate

$$Q = 2400 \text{ SCFM} \times 1.08 \frac{\text{BTU}}{^{\circ}\text{F} \times \text{SCFM} \times \text{hr}} \times 74.5^{\circ}\text{F} = 193{,}104 \text{ BTU/hr}$$

Savings = 442 hr x 193,104 BTU/hr x $3.95/$10^6$ = $337

% of gas consumption for Feb. = ($337/$3,679.64) x 100% = 9.2%

Payback Period

Installed cost	$ 17,500
Yearly savings (estimated, $337 x 5 months)	1,685
Payback = $\frac{\$17{,}500}{\$\ 1{,}685/\text{year}}$	10.4 yrs.

CONCLUSIONS

A thermosyphon heat exchanger can be used to recover waste heat from contaminated exhaust flows.

The use of this type of unit is particularly practical when mixing of contaminated exhaust and inlet air must be prevented. It is estimated that the use of this heat exchanger at Inventronics will generate $1,685 in annual savings based on a two shift operation.

RECOMMENDATIONS

Monitoring and payback analysis are based on only one month of operation. A full season of controlled monitoring is required to determine an accurate payback.

In this project, the heat pipe was used to recover heat for space heating purposes (process-to-comfort). Better utilization and faster payback could be achieved by running in a process-to-process recovery mode, which would generate the recovery throughout the year rather than only during the winter heating season.

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